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UNITED STATES BUREAU OF MINES
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AMBER

BY

ALICE V. PETAR

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AMBER [1]

By Alice V. Petar [2]

INTRODUCTION

Like many gem materials, amber has a colorful history which may be traced through the writings of the ancients and the ornamental relics discovered from time to time. Like few gem materials, however, it is distinctly useful in products whose value has no connection with the gem industry. Long prized for its beauty, amber was fashioned into articles of jewelry and ornaments to please the fancy of ancient rulers and to find a place among treasured possessions in their tombs; it has been used by adherents of various creeds for rosaries and other religious symbols; and although still sold for these purposes it also lends itself to such commercial purposes as raw material for varnish.

Amber is only on the border-line of the mineral kingdom; actually it is of vegetable origin, having been formed as resin from trees of the conifer family that existed during the Tertiary period. It is the hardest of the fossil gums.

The United States produces no amber, although a few occurrences are known. Most of the world's supply comes from East Prussia, where it is obtained from both land and sea. For many years pieces of amber were gathered from the Baltic by fishermen and deep-sea divers; and although about 10 percent of the Prussian amber is still recovered from the sea, most of the output is mined from open pits on the Samland Peninsula.

DESCRIPTION AND PROPERTIES

Amber or succinite is one of the softest (hardness, 2 - 2.5, Moh's scale) gem materials and is only fractionally heavier than water (specific gravity, 1.05 - 1.096). It is a yellow, reddish, or brownish transparent to translucent fossil resin. Amber may include occasional fragments of insects, flowers, leaves or other vegetable remains, which add to the value. Amber begins to soften at 150° and melts at 250° to 300°. It is easily electrified by rubbing with a cloth.

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1. The Bureau of Mines will welcome reprinting of this article, provided the following footnote acknowledgement is used: "Reprinted from U.S. Bureau of Mines Information Circular 6789."

2 Rare Metals and Nonmetals Division, U. S. Bureau of Mines.

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USES

Although most persons associate amber with articles of jewelry and ornamental objects, only about 20 percent of the amber produced is in pieces large enough and sufficiently pure to be used directly for these purposes. The remaining 80 percent is marketed as pressed amber or "amberoid", colophony, amber oil, and amber acid. Specimens of amber of unusual color, shape, or size or containing fragments of insects or leaves are prized by collectors.

Amber for ornamental use is first sorted as to color, form, and dimensions. With respect to color it may be classified as: [3]

1. Clear and transparent.
2. Dull but also translucent and only slightly cloudy (owing to air bubbles included).
3. "Bastard", of darker hue but still almost diaphanous.
4. "Bony", not transparent and whitish.

The following classifications relate to shape:

1. Large, flat, and mostly cloudy "tiles" and "plates".
2. Roundish, opaque "tears", sometimes flattened at the bottom.
3. Fine and clear "pouches", which frequently contain animal and plant inclusions.

The pieces of amber are trimmed by hand with keen-edged tools, and the workman endeavors to determine at the outset the use to which the lump is best adapted, to eliminate waste insofar as possible. The articles to be produced are divided into four principal classes:

1. Gems (necklaces, bracelets, brooches, earrings, pendants, finger rings, cuff buttons, teething rings for children).
2. Smoking articles (cigar and cigarette holders, mouthpieces for pipes).
3. Objects of art (carvings, jewelry boxes, cups and dishes, writing utensils, ornaments).
4. Devotional articles (Catholic, Moslem, and Buddhist rosaries, sacred figures, amulets).

The following paragraph quoted by Ravndal [4] gives some idea of the value attached to amber ornaments by various peoples all over the world:

> Strings of beads from the purest, dim, dull-yellow kinds of amber are most popular with the Oriental and English ladies; the more bone-like, whitish kinds are the preferred ornaments of the inhabitants of West and East Africa; the light and clear ones go to the Caucasus; the finest clear ones to France, Brunswick, and Tartary; the inferior ones are used in Russia and interior Africa. The Chinese and Corean official

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3 Ravndal, G. Bie, Am. Consul General, Berlin, Amber: Cons. Rept. 324102, Nov. 16, 1929.

4 Ravndal, G. Bie, work cited.

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is probably as proud of possessing a long mandarin-chain of amber as the American Indian is of his ear-cobs of the same material. About 10,000 prayer-wreaths of amber pass every year into the hands of devout Moslems, and a far greater number of rosaries of like material to Southern France, Spain, and Italy. The warrior in Morocco wears his amber amulet on his chest like the Chinese warrior. And many Persians adorn not only themselves and their dead but even their horses with strings of clear, chinked amber beads which often are as big as eggs.

The finishing work is done entirely by hand; great skill is required, particularly in carving the ancient dieties, animals, and objects of art.

Amberoid

Clear pieces of amber too small or too irregular in shape for any of the above uses are employed for pressed amber. To prepare this material the weathered crust and impurities are peeled off and the pieces of amber are exposed to a temperature of 170° to 190° until they become pliable. They are then placed in a strong, deep, steel tray with a perforated cover and pressed together at 200° C. The pliant amber is forced up through the holes in the cover and in cooling solidifies into a flat mass, which is fabricated in the same fashion as natural amber.[5] Pressed amber has the advantage that the articles to be made are not restricted as to size. Industrial uses to which pressed amber is adapted include the manufacture of test tubes, beakers, dishes, and insulating materials, as well as many articles for which natural amber is employed.

Distillation Products

Pieces of amber too small and dirty to be made into pressed amber are subjected to dry distillation in iron retorts. By this treatment 60 to 65 percent of amber colophony or resin, 15 to 20 percent of amber oil, and 2 percent of acid are recovered.

The colophony is used for high-grade amber varnish. The oil is also used for this purpose and in metal casting and flotation, as well as in wood preservatives and insecticides for trees. Amber acid is used for pharmaceutical purposes and in the manufacture of rhodamine dyes.

SUBSTITUTES

Many resins are somewhat similar to amber. More than 20 are described in Dana's System of Mineralogy, but none have more than mineralogical interest.

Reconstructed amber or amberoid (see also Uses) frequently is employed as a substitute for natural amber; except for the addition of minute quantities of color, it contains no foreign substance. A recent article [6] describes this material as follows:

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5 Manufacturing Jeweler, Amber: Vol. 92, no. 3, Feb. 2, 1933, p. 21.
6 Manufacturing Jeweler, work cited.

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This reconstructed amber is harder than the natural amber, but by no means as bright, and does not afford the same high polish. Moreover, amberoid quickly undergoes a change. The cirrus clouds, which appeal to some in amber and appear in the process of manufacturing amberoid, become, after a few months, unpleasant in appearance, while articles made from the transparent amberoid lack the luster and warmth of those made from a natural mass because the structure reveals undulating lines much the same, one might say, as synthetic rubies reveal circular lines instead of the straight or angular forms which characterize crystals.

Other products used extensively in place of amber for ornamental objects, mouthpieces for pipes, cigarette holders, etc., include synthetic phenolic resins, prepared by the chemical combination of a phenol with formaldehyde. They are chemically more stable than amber; their domestic manufacture has increased from 3,094,534 pounds in 1919 to 13,452,230 pounds in 1927. Imports have likewise increased enormously - from 1,114 pounds in 1919 to 60,547 pounds in 1928. 7

Artificial amber may be distinguished from genuine by applying heat; the synthetic product when heated throws off a strong smell of carbolic acid. Another test is described as follows: 8

In a saturated solution of tablesalt the phenolic imitation sinks to the bottom, whereas the true amber and the copal gum imitation float on the top of the liquid. The copal imitation is disclosed by its reaction in contact with sulphuric ether (purchasable at any chemist's store), which attacks the copal but not the amber. The phenolic product also withstands the ether just as well as amber.

HISTORY

References to amber appear in some of the earliest published writings. The presence of amber products in the tombs of the Phoenicians, Assyrians, Greeks, and Romans indicates that this material has been valued for many centuries. The power of electrified amber to attract and the fact that many of the specimens contain fragments of insects has resulted in interesting superstitions with reference to its origin. Pliny, for example, relates that the sisters of Phaethon, changed into poplars, shed their tears on the banks of the Eridanus (or Padus). He also states that amber was used for hygienic purposes; farmers' wives where the water was "bad" (deficient in iodine) wore amber jewelry around their necks as a remedy against swellings (goiter).

The following notes on the early history of amber are of interest: 9

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7 U. S. Tariff Commission, Summary of Tariff Information, 1929: Sched. I, pp. 81 and 147.
8 Jewelers' Circular, Tests for Amber; Vol. 88, July 2, 1924, p. 53.
9 Beichert, Walter J., Amber: Rocks and Minerals, vol. 7, March 1932, p.4.

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Homer makes no mention of any gem in his minute description of various jewels, save the amber which decorated the gold necklaces offered by the Phoenician trader to the Queen of Syria. It was one of the seven sages of Greece, Thales of Miletus, who discovered the remarkable property which amber possesses, when rubbed, of attracting light bodies. This is the very oldest experiment recorded in the annals of electrical science. Indeed the word "electricity" comes from the word "electron", the Greek name of amber. Possibly the word "electron" itself had reference to the characteristic yellow color of amber, for it is noticeable that a pale yellow alloy of gold and silver was also called electron. As to our own modern word "amber", it comes, like so many of our scientific words, from an Arab source.

By the Romans amber was so highly prized that Pliny tells us a small figure carved from this substance would fetch in his day more than a healthy slave. Roman ladies at one period were in the habit of carrying a ball of amber in the hand, for the sake of the delicate balsamic odor which it emitted when warmed in this way.

During the thirteenth century and later, amber was used extensively for ornaments, the workmanship being handled chiefly by turners' guilds in northern Europe. According to a report on amber by the American consul general in Berlin November 16, 1929:

> Graceful powder boxes and smelling bottles were brought into existence, often carved from a single chunk and studded with filigree of gold or silver and with precious stones. The baroque age influenced also the amber art, and quaint jewel caskets and millinery chests, nay, even cupboards with pillars, walls, and doors in different colors, date back to this period. Of amber were also made costly reliefs, mirror frames, goblets, and vases inlaid with gold or silver or enamel. Museums in Berlin, Dresden, and Moscow contain wonderful specimens of artistic amber products of earlier days.

OCCURRENCE

The original resin which fossilized into amber was exuded from trees not unlike our pine trees of today. Knowledge of the origin of amber is derived in part from discoveries of pieces of wood intimately associated with amber and entrapped insects. Several resins that resemble amber are now being formed, but the particular variety of conifer which was the source of true amber is no longer in existence. Geologically, amber is older than other fossil resins, and it is further distinguished from most of them by the presence of small amounts of sulphur and succinic acid.

Although occurrences of amber and amberlike resins have been found in many parts of the world the principal deposits are in Germany (East Prussia) along the shores of the Baltic Sea. The amber is found in "blue earth", a loose, bluish, clayey sandstone. Other occurrences of amber have been noted in Lithuania, England, Russia, Italy, and Burma, and on the coasts of Denmark and Sweden. Of the rather widespread deposits of amberlike resins, the few found in the United States are associated with greensand formations, as at

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Gay Head or Martha's Vineyard; near Trenton, at Camden, and elsewhere in New Jersey; and at Cape Sable, near the Magothy River, in Maryland. A mass found in the marl pits near Harrisonville, Gloucester County, N. J., weighed 64 ounces. [10] An occurrence of amber at Kreischerville, Staten Island, was discovered by Dr. Arthur Hollick in 1904. [11]

MINING AND PREPARATION

The blue-earth deposits of East Prussia and the contiguous territory of Lithuania, from which most of the world's supply of amber is derived, lie along the coast of the Baltic Sea and extend far out into the sea. The nearly horizontal bed of blue earth is about 130 feet below the surface at the coast but is uncovered on the floor of the sea several hundred yards from land. Pieces of amber are naturally washed ashore from time to time; commercial production at first was obtained only by beach combers, fishermen, and deep-sea divers. At present, however, only 10 percent of the output comes from the sea. About the middle of the last century shafts were sunk on land, and underground mining was carried on for a number of years. The porosity of the overburden and the presence of quicksand finally (1923) made advisable a change to open-pit mining. Each year this necessitates the removal of some 30,000,000 cubic feet of barren material overlying the stratum of blue earth. The steps involved in removing this overburden, raising the blue earth, and extracting the amber are described in considerable detail by Friedrich Prockat. [12]

> The blue earth, bearing the amber, is raised to the surface on an incline in cars of 5.3 m^3 capacity. * * * For further treatment the blue earth is transported to Palmnicken by means of electric locomotives. The cars are emptied over a grate in the so-called spray house, and the blue earth is pulped, with sea water under a pressure of six atmospheres, by the flushing methods familiar in the extraction of gold from sands. The larger amber pieces are collected by hand; the smaller ones flow on with the clay slurry, on which they float because of their low specific gravity - under 1.5. It is thus possible to remove the heavy material from the channel, as in coal technology, while the amber-bearing slurry flows on to a classifying drum, where the amber is segregated into different sizes. The larger pieces are cleaned of their crust in special wooden drums to which sand and soda solution are added. At the sorting, which is done at Königsberg, these are again beaten by hand, so that only clean amber will be sent to the market.

The preparation of amber for marketing is further described under Uses.

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10 Dana, J. D., The System of Mineralogy: New York, 6th ed. revised by E. S. Dana, 1911, p. 1003.

11 Kunz, George F., Precious Stones: U. S. Geological Survey, Mineral Resources of the United States, 1904, p. 960.

12 Prockat, Friedrich, Amber Mining in Germany: Eng. and Min. Jour., vol. 129, Mar. 24, 1932, pp. 305-307.

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In Burma mining methods are primitive, as indicated by the following description: 13

> The amber mines are really shallow wells about 3 feet 6 inches square and with a maximum depth of about 45 feet. The number of coolies working a pit varies from 2 to 4, but generally 3 people work together. One man digs underground with a hoe, the second hauls the debris up and looks for amber in it, while the third dumps the spoil. The deep pits, especially when they are in the soft shales and close to one another, are lined with thin bamboo barricades. Water is bailed out by hand methods. Mining is continued till, according to the miners, a layer of sand, termed "Khumtsai" by the Kachins and "sai" by the Shans, is reached, beneath which they believe that no amber occurs.

WORLD PRODUCTION

No amber is produced in the United States; except for relatively insignificant quantities reported by Rumania, British India, and Lithuania virtually the entire output of crude amber originates in Prussia. Production statistics for the period 1924-32, inclusive, are shown in the following table.

World production of amber, 1924-32, inclusive, in metric tons

	Prussia	Rumania	British India
1924	501	0.230	4.521
1925	547	.140	.813
1926	540	.140	2.032
1927	414	.156	3.607
1928	481	.030	1.524
1929	516	.020	1.016
1930	491	.107	.107
1931	314	.104	---
1932	59	.060	.575

In addition, Lithuania produces about 1 ton of crude amber annually.

IMPORTS

Pre-war imports of amber and amberoid ranged from 30,000 to 60,000 pounds annually. Within the past decade, however, imports have declined noticeably, amounting to only 163 pounds in 1932 and 567 pounds in 1933. Available statistics covering imports of amber and amber products from 1919 to 1933, inclusive, are set forth in the following table:

13 Fermor, L. L., General Report of the Geological Society of India for the year 1930: Rec. Geol. Survey of India, vol. 65, pt. 1, 1931, pp.33-34.

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Imports of amber and amber products, 1919-33, inclusive

Year	Amber and amberoid (unmanufactured)		Manufactures of amber 1/		Amber oil	
	Pounds	Value	Pounds	Value	Pounds	Value
1919	768	$ 4,278	----	$ 2,466	4,819	$4,837
1920	15,013	41,556	----	21,843	1,312	513
1921	3,094	20,438	----	9,862	468	160
1922	2,766	25,580	2/ 3,645	2/ 9,988	1,772	845
1923	2,172	24,773	2,901	43,185	44	9
1924	2,778	28,766	2,699	42,834	1,200	605
1925	3,390	29,284	1,716	29,385	1,000	400
1926	3,778	25,732	----	6,982	3,297	627
1927	1,881	12,604	----	5,032	1,272	290
1928	981	6,935	----	15,122	3,065	312
1929	1,414	9,537	----	13,925	4,545	251
1930	939	6,187	----	3,944	3/ 2,044	3/ 74
1931	818	4,776	----	1,465	-----	----
1932	163	902	----	-----	-----	----
1933	567	2,781	----	-----	-----	-----

1/ Miscellaneous minor items only. The more important amber products such as beads, holders for cigars and cigarettes, and mouthpieces for pipes are dutiable and hence reported more specifically under other classifications of the Tariff Act.

2/ Includes manufactures valued at $6,037 during first 9 months, for which quantity was not reported.

3/ January 1 to June 17, inclusive.

TARIFF

The Tariff Act of 1930 provides for the following duties on amber and manufactures of amber:

Par. 11: Amber and amberoid unmanufactured, not specifically provided for, 50 cents per pound.

Par. 1536: * * * manufactures of amber, bladders, or wax, or of which these substances or any of them is the component material of chief value, not specially provided for, 20 percentum ad valorem.

The principal manufactures of amber, such as beads, cigar and cigarette holders, and pipe stems, are more specifically provided for under other paragraphs relating to such respective items.

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THE INDUSTRY IN FOREIGN COUNTRIES

Germany

Deposits of amber occur all along the coast of the Baltic from Danzig to Memel, but the principal source of supply is at Palmnicken on the Samland Peninsula, East Prussia. The exploitation of these deposits was first undertaken by the State in the Middle Ages, and it was decreed that all amber found must be delivered to the Government in return for a specified compensation. Later, mining rights were acquired by private persons, only to be transferred back to the Government, and so on, back and forth. Since 1899 the State of Prussia has controlled the Baltic amber deposits, exploiting them through the Preussische Bergwerks-und Huetten-Aktiengesellschaft. In March 1926 the leading German amber factories organized a manufacturing and sales agency, the Staatliche Bernstein-Manufaktur G.m.b.H., in which the Preussische Bergwerks- und Huetten-Aktiengesellschaft is represented. The headquarters of the organization are at Königsberg. [14] In addition, there are 12 to 20 independent manufacturers who purchase amber chiefly from the common source but also obtain supplies of raw material from sources not controlled by the State monopoly (near Rügen and the waters of Danzig, Riga, and Libau) and sell at their own prices. [15]

Ordinarily, the Preussische Bergwerks-und Huttten A. G. employs 600 to 700 men at Palmnicken in the mining, preliminary sorting, and treating of amber and an additional 150 men at the factory at Königsberg. [16] The Free City of Danzig has also been an important manufacturing center for amber products, employing about 600 workmen. [17]

It has been estimated that about 25 percent of the articles manufactured from amber remain in Germany, the balance being exported to foreign countries. Mesopotamia and Persia provide substantial markets for Mohammedan rosaries, which are required to be of amber.

Early in 1932 amber production in Germany was suspended as a result of the decline in sales and the accumulation of stocks sufficient to meet the demand for 2 or 3 years. [18] In an effort to aid the industry the National Socialist press department issued an appeal to all sporting societies to use amber prizes and decorations for sport records and games in place of gold and

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14 Staatliche Bernstein-Manufaktur G.m.b.H., Amber: German Commerce Yearbook, 1930-31, pp. 226-230.

15 Ravndal, G. Bie, American consul general, Berlin, Amber: Cons. Rept. 324102, Nov. 16, 1929.

16 Prockat, Friedrich, Amber Mining in Germany: Eng. and Min. Jour., vol. 129, no. 6, Mar. 24, 1930, p. 307.

17 Kemp, Edwin C., American consul, Danzig, The Danzig Amber Industry; Comm. Repts., Apr. 27, 1925, p. 212.

18 Bureau of Foreign and Domestic Commerce, World Trade Notes on Chemicals and Allied Products: Vol. 6, no. 50, Dec. 12, 1932, p. 6.

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silver. [19] By March 1934 improved trade conditions had enabled the German amber mining industry to resume normal operations, increased sales of amber having absorbed virtually all the accumulated stocks. [20] Exports of amber from Germany during recent years have been as follows: [21]

Exports of amber and amber products, 1929-32

	1929 (kilos)	1930 (kilos)	1931 (kilos)	1932 (kilos)
Raw and scrap amber	76,000	49,700	30,300	13,800
Manufactured amber	27,800	14,600	8,600	

Lithuania [22]

Although Prussia is by far the leading producer of amber and amber products, the industry in Lithuania operates on a greatly reduced scale. The small seacoast of Lithuania adjoining the rich amber beds of Samland furnishes an average of about 1 metric ton of amber annually. As in Prussia, the industry is controlled by the Government. Persons finding amber must deliver the pieces to the State; failure to do so renders the finder liable to a charge of embezzlement. The small domestic supply of amber is augmented by imports from Prussia, amounting to about 5 metric tons annually. In Lithuania amber products are manufactured at 10 factories employing 112 persons.

Burma

A ton or two of amber is produced in Burma each year. The amber is somewhat harder than that from the Baltic area; the color is described as "bright, pale-sherry yellow, and a reddish tint which fades into a dirty brown." [23] The amber mines are about 3 miles southwest of the village of Shingban in the Myitkyina district (northeastern Burma). According to local inhabitants, amber has also been found in the past in the Kapdup Kha, although the exact locality is not known to the present generation. [24] Burmese amber is used in the manufacture of rosaries and ornaments.

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19 Bureau of Foreign and Domestic Commerce, World Trade Notes on Chemicals and Allied Products: Vol. 7, no. 41, Oct. 9, 1933, p. 3.

20 Redecker, Sydney B. German Amber Trade Reviving: Excerpt from German Chemical Notes, Cons. Rept. 10996, Mar. 3, 1934.

21 Bureau of Foreign and Domestic Commerce, World Trade Notes on Chemicals and Allied Products: Vol. 6, no. 36, Sept. 5, 1932, p. 12.

22 Kuniholm, Bertel E., American vice consul, Kovno, Amber Production in Lithuania: Comm. Repts., Sept. 16, 1929, pp. 744-745.

23 Moffitt, J. P., American Consul, Rangoon, Burma, Production of Jade, Amber, and Precious Stones in Burma: Cons. Rept. 100832, May 28, 1923.

24 Fermor, L. L., General Report of the Geological Society of India for the Year 1930: Rec. Geol. Survey of India, vol. 65, pt. 1, 1931, pp. 33-34.

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Other Countries

Italy. - Although a little amber has been collected on the eastern and southeastern coasts of Sicily, it is not abundant enough to maintain an established industry. Some specimens of Sicilian amber display a remarkable play of colors. 25

Rumania. - A small quantity of amber (normally, 100 to 200 kg annually) is produced in Rumania. The amber of Buzau is said to be unusually beautiful, but mining is costly because of the depth at which the amber occurs. The best amber, known as "sidef" (mother-of-pearl), is used for making cigarette holders and ornamental objects. 26 The bluish-green, brown to nearly black amber from the Almash Valley near Piatra in the district of Neamtu is known as "almashite" and that from beds at Olanesti in the Valcea district, as "Muntenite." 27

Amber has also been found on the western coast of Denmark, in the Magallanes district of Chile, associated with coal on the northeast coast of Kuji, Japan, and at various other localities.

PRICES

The import statistics, representing the average foreign market value of shipments of crude amber and amberoid to the United States, indicate a range in price from $2.768 a pound in 1920 to $11.406 in 1923, with a general downward tendency since 1923.

Prices paid by the Lithuanian Government for raw amber range from $1.50 for pieces the size of a hazelnut to $29 for 500-gram specimens. Pieces with holes, cracks, and chinks bring lower prices and especially good pieces, one fourth more than the quoted price. At Kovno finished amber commands the following prices: 1st class, $120 per kg; 2d class, $80 per kg; and 3d class, $40 per kg. 28

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25 Myers, W. M., The Commercial Recovery of Fossil Gums: Chem. and Met. Eng., vol. 31, Oct. 20, 1924.

26 Iancoulesco, Aurel P., Les Richesses minières de la nouvelle Roumanie: Paris, 1928, 380 pp. Abstracted in Imperial Inst. Bull., vol 27, no.3, 1929, p. 436.

27 Murgoci, G., The Roumanian Ambers, Their Scientific and Economic Importance: Correspondence écon. roumaine, Bull. officiel, Ministère de l'Ind. et du Comm., Bucarest, vol. 6, 1924, pp. 3-25; Chem. Abs., vol. 25, no. 13, 1931, p. 3277.

28 Kuniholm, Bertel E., American vice consul, Kovno, Lithuania: Voluntary Rept. 315496, Aug. 7, 1929.

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